

APPENDIX A

Table A1. Element to oxide conversion factors

Ag ₂ O.....1.0741	CuO..... 1.2518	Lu ₂ O ₃ 1.1371	PtO1.0820	ThO ₂ ... 1.1379
Al ₂ O ₃1.8895	Dy ₂ O ₃ 1.1477	MgO 1.6582	Rb ₂ O1.0936	TiO ₂ 1.6681
As ₂ O ₃1.3203	Er ₂ O ₃ 1.1435	MnO 1.2912	ReO.....1.0859	Tl ₂ O ₃ ... 1.1174
As ₂ O ₅1.5339	Eu ₂ O ₃ 1.1579	MnO ₂ 1.5825	RhO.....1.5555	Tm ₂ O ₃ . 1.1421
Au ₂ O.....1.0406	FeO 1.2865	MoO ₃ 1.5003	RuO.....1.1583	UO ₂ 1.1344
B ₂ O ₃3.2202	Fe ₂ O ₃ 1.4297	NO ₃ 4.4267	SO ₃2.4972	UO ₃ 1.2017
BaO 1.1165	Ga ₂ O ₃ 1.3442	Na ₂ O 1.3480	Sb ₂ O ₅1.3284	U ₃ O ₈ 1.1792
BeO2.7758	Gd ₂ O ₃ 1.1526	Nb ₂ O ₅ 1.4305	Sc ₂ O ₃1.5338	V ₂ O ₅ 1.7852
Bi ₂ O ₅1.1914	GeO ₂ 1.4408	Nd ₂ O ₃ 1.1664	SeO ₃1.6079	WO ₃ 1.2610
CO ₂3.6644	HfO ₂ 1.1793	NiO.....1.2725	SiO ₂2.1392	Y ₂ O ₃ 1.2699
CaO1.3992	HgO.....1.0798	OsO 1.0841	Sm ₂ O ₃1.1596	Yb ₂ O ₃ .. 1.1387
CdO1.1423	Ho ₂ O ₃ 1.1455	P ₂ O ₅2.2916	SnO ₂1.2696	ZnO 1.2448
Ce ₂ O ₃1.1713	In ₂ O ₃ 1.2091	PbO.....1.0772	SrO.....1.1826	ZrO ₂ 1.3508
CeO ₂1.2284	IrO1.0832	PbO ₂1.1544	Ta ₂ O ₅1.2211	
CoO1.2715	K ₂ O 1.2046	PdO.....1.1504	Tb ₂ O ₃1.1510	
Cr ₂ O ₃1.4615	La ₂ O ₃ 1.1728	Pr ₂ O ₃ 1.1703	Tb ₄ O ₇1.1762	
Cs ₂ O.....1.0602	Li ₂ O2.1527	Pr ₆ O ₁₁ 1.2082	TeO ₃1.3762	

Table A2. Weight-to-ppm-to-ppb equivalents

<i>Weight percent</i>	<i>ppm</i>	<i>ppb</i>	<i>ppt</i>	
1.0	10,000			
0.1	1,000			
0.01	100			
0.001	10			
0.0001	1	1,000		1 µg/g or 1mg/L
0.00001	0.1	100		
0.000001	0.01	10		
0.0000001	0.001	1	1,000	1ng/g or 1µg/L
0.00000001	0.0001	0.1	100	
0.000000001	0.00001	0.01	10	
0.0000000001	0.000001	0.001	1	1pg/g or 1ng/L

Table A3. Grain size and sieve equivalents

<i>Mesh opening</i>		<i>U.S. Standard Mesh No.</i>	<i>Tyler Mesh Equivalent</i>
<i>Microns</i>	<i>Inches</i>		
850	0.0331	20	20
710	0.0278	25	24
600	0.0234	30	28
500	0.0197	35	32
425	0.0165	40	35
355	0.0139	45	42
300	0.0117	50	48
250	0.0098	60	60
212	0.0083	70	65
180	0.0070	80	80
150	0.0059	100	100
125	0.0049	120	115
106	0.0041	140	150
90	0.0035	170	170
75	0.0029	200	200
63	0.0025	230	250
53	0.0021	270	270
45	0.0017	325	325
38	0.0015	400	400

APPENDIX B

GLOSSARY OF SYMBOLS AND TERMS

Å—angstrom (unit of wavelength measure equal to one ten-thousandth of a micron, or 1×10^{-8} cm)

A—ampere. Unit of electric current, defined as the current that passes through a resistance of one ohm when a potential difference of 1 volt is applied.

A—absorbance

AAS, atomic absorption spectrometry—analytical technique based on the absorption of radiant energy by atoms. The wavelength and quantity of absorbed radiation is characteristic and proportional to the concentration of specific atoms.

ac—alternating current

Accuracy—degree of agreement between the measured value to the “true” or proposed value

AES, atomic emission spectrometry—analytical technique based on the emission of radiant energy by atoms. Free atoms (elements) are excited by a source of energy. As the excited atoms return to the ground state, they emit a characteristic radiation with an intensity proportional to the concentration of the atoms.

Aliquot—measured volume of a liquid which is a known fractional part of a larger volume

Anion—negatively charged ion, e.g. Cl^- , SO_4^{2-} , and PO_4^{3-}

Anode—electrode at which oxidation occurs and toward which anions move

Aqua regia—mixture of 3 parts 12 M HCl with 1 part 16 M HNO_3

Batch—quantity of test samples produced during an analytical process expected to be of uniform character

Bias—positive or negative deviation of the mean analytical result from the proposed or “true” value

Blank—the measured value of a sample that is as free as possible of the analyte of interest

c—cycle

°C—degree Celsius

Calibration—comparison of a measurement standard with a sample to report or eliminate by adjustment any variation in the accuracy of the measurement value

Cation—positively charged ion, e.g. Na^+ or Fe^{2+} , Fe^{3+} , and NH_4^+ .

Chemical hygiene plan—written document of a comprehensive laboratory safety program.

Chromatography—the separation of mixtures into their constituents by preferential absorption by a solid.”

cm—centimeter

Combustion—means of sample decomposition. Usually the sample is oxidized and the volatile compounds are separated and measured for the element (e.g. carbon, sulfur, and hydrogen) of interest

conc—concentrate

Coulometry—analytical technique measuring the quantity of electricity used to carry out a chemical reaction in solution. The number of coulombs required is directly proportional to the amount of oxidation/reduction (ion concentration) at the electrode.

db – decibel

dc – direct current which flows in only one direction

DNA, delayed neutron activation analysis – technique based on neutron irradiation of samples inducing nuclear fission products. The subsequent decay by delayed neutron emission can be quantitatively counted for specific species (uranium and thorium).

Duplicate sample – a second aliquot of a randomly selected sample to assist in the evaluation of laboratory variance

Flame photometry – analytical technique based on the emission of radiation by atoms in a flame returning from an excited state (formed due to absorption). The wavelength and intensity of light emitted is proportional to a specific element and concentration.

g – gram

Graphite furnace – a device used to atomize a sample by electrically generated heat (about 2500°C) for AAS analysis. A nitrogen or argon atmosphere is circulated through the device to prevent air oxidation.

Gravimetric analysis – Analysis by weight measurement, process where the weight of the product of a reaction (precipitate, gas, or pure metal in electroplating) is measured and converted back to the weight of a specific species.

Heavy metals – those metals which have ions that form an insoluble precipitate with sulfide ion

hp – horsepower

Hydride – compound of hydrogen, specifically containing H⁻ ions.

ICP, inductively coupled plasma – a plasma used as an excitation source for samples. The device creates a plasma (about 10,000 K) by interacting an induced magnetic field with argon gas.

id – interior diameter

in – inch

INAA, instrumental neutron activation analysis – technique based on the irradiation of samples by neutrons producing a radioactive isotope. The isotope emits characteristic gamma radiation in amounts indicative of specific elemental concentrations.

ISE, Ion-selective electrode – half-cell consisting of a thin pH responsive membrane (glass, lanthanum fluoride, liquid, or gas permeable) housing an internal reference reservoir. The potential measured in an external solution is proportional to the logarithm of the ion concentration.

k – the number of subgroups or samples under consideration

λ – lambda; the wavelength of light or x-radiation. Also the decay constant of a radioactive isotope.

μg – microgram (1×10^{-6} gram)

μm – micrometer (micron)

L – liter

LLD, lower limit of determination – the lowest quantitative concentration level of the analyte that can be determined with a stated 5s level of confidence

LOD, limit of detection – the lowest qualitative concentration level of the analyte that can be determined with a stated 3s level of confidence

LOQ, limit of quantification – the lowest quantitative concentration level of the analyte that can be determined with a stated 5s level of confidence

Mass spectrometry – analytical technique based on the determination of the mass/charge ratio of an ion. Molecules are broken into charged particles and separated by a magnetic field. The fragments strike an electron-emitting surface generating a characteristic electrical signal. The relative numbers of each kind of ion is specific for a given compound (including isomers and organic mixtures).

Method blank – an empty sample container which is carried through the entire analytical procedure.

mg – milligram (1×10^{-3} gram)

min – minute

mL – milliliter

mm – millimeter

MSDS – Material Safety Data Sheets; documents required by OSHA regulations on all chemicals detailing their possible health, fire, and other risks.

n – the number of observed values in a sample or subgroup, sample size

ng – nanogram (1×10^{-9} gram)

od – outside diameter

OSHA – U.S. Department of Labor's Occupational Safety and Health Administration

Oxidation – half-reaction involving a loss of electrons; a positive charge in valence

oz – ounce

pct – percent

pH – measure of hydrogen-ion concentration of a solution, defined as $-\log_{10}[\text{H}^+]$

Potentiometry – analytical technique based on 1) the measurement of the changes in electromotive forces through titration or 2) the direct measurement of an electrode potential

ppb – parts per billion

ppm – parts per million

psi – pounds per square inch

Precision – degree of agreement between measured values under repetitive testing of a sample; reproducibility of results

pv – proposed value

QA, quality assurance – a preventative program to assure that a product or service meets defined standards of quality

QC, quality control – the procedures used to ensure acceptable quality results are produced

***R*, sample range** – the absolute difference between the minimum and maximum values of a data set

%*R*, percent recovery – the ratio of the observed value, *X* to the proposed value *pv*, expressed as a percentage,

$$\%R = \frac{X}{pv} \times 100$$

Reduction – half-reaction involving a gain of electrons; a negative charge in valence.

RF – radio frequency

RM, reference material – sample having one or more well established properties to be used for calibration, assessment of a measurement method, or assignment of values to materials.

rpm – revolutions per minute

%RSD, relative standard deviation – the ratio of standard deviation, s to the arithmetic mean \bar{X} , expressed as a percentage,

$$\%RSD = \frac{s}{\bar{X}} \times 100$$

s – second

sensitivity – the ratio of change in signal to the change in analyte concentration

s, standard deviation – the square root of the quantity (sum of squares of deviations of individual results from the mean, divided by one less than the number of results in the set),

$$s = \sqrt{\sum_{i=1}^n (X_i - \bar{X})^2 / n - 1}$$

s_d , standard deviation for duplicate measurements – the square root of the quantity (sum of squares of the difference between the duplicate results, divided by two times the number of sets of duplicate samples),

$$s_d = \sqrt{\sum R^2 / 2k}$$

Sample – representative part of a larger whole, any quantity of the test (field) or reference substance

Specific gravity – ratio of the density of a substance to the density of a standard substance

Titrimetry – volumetric analysis by which the exact amount of reagent needed to combine with a specific species is measured. The total consumption of the species is signaled by a physical change (e.g. change of color, turbidity formation, conductivity) in the solution. The amount of the reagent needed is converted to the weight of the species.

v , degrees of freedom – defined as $n-1$, refers to the number of independent deviations which are used in calculating standard deviation

X – observed value of a measurable characteristic

\bar{X} , arithmetic mean – the sum of n observed values divided by n ,

$$\bar{X} = (X_1 + X_2 + \dots + X_n) / n$$

XRF, X-ray fluorescence spectrometry – technique based upon analyzing the characteristic X-rays emitted by a sample. The sample is bombarded with X-rays from an X-ray irradiation source (tube or isotope), fluorescing characteristic X-rays proportional to the concentration of the element in the sample.